HIGH-SPEED OPTICAL RECORDING METHOD AND APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Application No. 2000-74311, filed December 7, 2000, in the Korean Patent Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a high-speed optical recording method and apparatus where marks can be erased at an optimal erasing rate even at high speed.

2. Description of the Related Art

[0003] Generally, optical recording/reproducing apparatuses use a single semiconductor laser to record a mark on an optical disc, and record an information signal on the optical disc by driving the semiconductor laser in a multi-pulse form according to the length of the mark to be recorded. For example, a phase change optical disc capable of repetitively recording is used as the optical disc, so that the recording of the mark is performed while erasing an existing mark previously recorded on the optical disc. Thus, an erasing signal is located on a period between recording signals, which corresponds to a length of the mark to be recorded.

[0004] Because the recording density is on an increasing trend and a high data transfer rate is demanding, a high recording rate is required and a fast erasing must be possible in order to obtain a high recording rate. However, because recording and erasing on the optical disc are generally performed by moving a single light spot emitted from the semiconductor laser and focused by an objective lens along a track, the light spot must move slower when erasing than when recording in order to achieve a desired erasing ratio, which is proportional to the time of radiation of the light spot. Hence, it is difficult to achieve fast erasing that satisfies a required high recording speed.

[0005] Fast erasing may be achieved by changing the structure of the optical disc. In existing systems, a crystallization accelerating layer is stacked on the upper and lower surfaces of a recording layer of the optical disc has been proposed in order to improve the

erasing ratio of a recorded mark. However, the thus-structured optical disc requires an increase in the number of stacks, thereby creating disadvantages in terms of yield and mass, production. Also, while crystallization is achieved well due to the existence of a crystallization accelerating layer, an adjacent track in the optical disc is affected by the crystallization during recording. Specifically, the mark recorded on the adjacent track is erased.

SUMMARY OF THE INVENTION

[0006] To solve the above problems, an objective of the present invention is to provide an optical recording method and apparatus by which a mark can be erased fast even when an optical disc has no special crystallization accelerating layers for accelerating erasing.

[0007] To achieve the above and other objects, the present invention provides an optical recording method, including: producing a main beam and a sub beam; forming a main light spot on an optical disc by projecting the main beam on the optical disc; forming a secondary light spot on the optical disc by projecting the sub beam onto the optical disc at a predetermined distance ahead of the main light spot in a track direction along which the optical disc rotates ; recording a new mark and erasing an existing mark using the main light spot; and supporting erasing of the existing mark using the secondary light spot during mark recording and/or erasing.

[0008] To achieve the above and other objects, the present invention provides an optical recording method, including: producing a main beam and a sub beam; forming a main light spot on an optical disc by projecting the main beam on the optical disc; forming a secondary light spot on the optical disc by projecting the sub beam onto the optical disc at a predetermined distance ahead of the main light spot in a track direction along which the optical disc rotates; supporting erasing of an existing mark using the secondary light spot during mark recording and/or erasing by partially erasing the existing mark while emitted at the predetermined distance ahead of the main light spot; completely erasing the existing mark partially erased by the secondary light spot during a recording signal period using the main light spot; and recording a new mark using the main light spot at a position of the erased mark.

[0009] Further, the secondary light spot partially erases the existing mark while emitted at the predetermined distance ahead of the main light spot in the track direction along which the optical disc rotates during a recording signal period, and the main light spot completely erases the existing mark partially erased by the secondary light spot during the recording

signal period.

[0010] To achieve the above and other objects, the present invention provides optical recording apparatus, including: a light source unit emitting a main beam to form a main light spot on an optical disc and emitting a sub beam to form a secondary light spot on the optical disc at a predetermined distance ahead of the main light spot in a track direction along which the optical disc rotates; and an objective lens focusing the main beam and the sub beam on a recording surface of the optical disc, wherein the main light spot records a new mark and erases an existing mark, and the secondary light spot supports the erasing of the existing mark during mark recording and/or erasing.

[0011] According to an aspect of the present invention, the light source unit includes: a light source producing and emitting light; and an optical branching device branching the light emitted from the light source into the main beam and the sub beam .

[0012] According to another aspect of the present invention, the light source unit includes first and second light sources positioned in the track direction of the optical disc and emitting the main beam and the sub beam, respectively.

[0013] Further, an optical erasing power of the main beam, Pme, and an optical erasing power of the sub beam, Pse, satisfy: Pme $\leq$ Pse. The optical erasing power of the main beam, Pme, is an invariable power including a predetermined magnitude, and the optical erasing power of the sub beam, Pse, is pulse-formed power.

[0014] Also, the main light spot and the secondary light spot projected on the optical disc are sufficiently separated from each other where the secondary light spot does not affect an area to be recorded on by the main light spot while erasing the existing mark. The predetermined distance between the main light spot and the secondary light spot on the optical disc is greater than a length of a minimum recording mark.

[0015] These together with other objects and advantages, which will be subsequently apparent, reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The above objective and advantage of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a diagram illustrating a part of an area of an optical disc on which a main light spot, Sm, and a secondary light spot, Ss, are formed in a track direction;

FIG. 2 is a schematic diagram of an optical structure of an optical pickup in an optical recording apparatus in accordance with an exemplary embodiment of the present invention;

FIG. 3 is a diagram illustrating an erasing effect varying according to a variation in DC erasing light power;

FIG. 4 is a diagram illustrating different magnitudes of the DC erasing light power applied to obtain the erasing effects illustrated in FIG. 3;

FIGS. 5A through 5C illustrate different degrees to which a mark is erased according to varying erasing pulse signals;

FIG. 6 is a graph showing an example of an erasing signal and a recording signal; and

FIG. 7 is a schematic diagram of the optical structure of an optical pickup in an optical recording apparatus in accordance with an alternative exemplary embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Referring to FIG. 1, a fast mark recording and/or erasing apparatus, in accordance with an exemplary embodiment of to the present invention, uses a main light spot, Sm, formed on an optical disc 10 and a secondary light spot, Ss, which is radiated or emitted at a predetermined distance ahead of the main light spot, Sm, along a track direction. The main light spot, Sm, is used to record and to erase an existing mark and the secondary light spot, Ss, is used to support the erasing of the mark performed by the main light spot, Sm.

[0018] In an exemplary embodiment, the main light spot, Sm, and the secondary light spot, Ss, on the optical disc 10 are sufficiently separated from each other so that the secondary light spot, Ss, does not affect the recording area to be irradiated by the main light spot, Sm, while erasing the existing mark. To be more specific, preferably, the distance between the main light spot, Sm, and the secondary light spot, Ss, on the optical disc 10 is greater than a minimum recording mark length, for example, 3T.

[0019] A main beam I and a sub beam II are emitted by a light source, to be later described, and form the main light spot, Sm, and the secondary light spot, Ss, respectively, on the surface of the optical disc 10. Also, an optical erasing power of the main beam I and an optical erasing power of the sub beam II satisfy the following equation:

$$Pme \leq Pse \qquad (1)$$

[0020] where Pme denotes the optical erasing power of the main beam I and Pse denotes the optical erasing power of the sub beam II. Here, the optical erasing power of the main beam I is an invariable value of a predetermined magnitude (hereinafter, referred to as optical DC erasing light power, Pe), and the optical erasing power of the sub beam II has a pulse form that is the same as the pulse form of a recording signal.

[0021] FIG. 2 is a schematic diagram of a structure of an optical pickup in an optical recording apparatus, in accordance with an exemplary embodiment of the present invention. As shown in FIG. 2, in order to form the main light spot, Sm, and the secondary light spot, Ss, on the optical disc 10, the optical recording apparatus includes a light source unit 11 to produce the main beam I and the sub beam II. An objective lens 21 focuses the main beam I and the sub beam II received from the light source unit 11 so that the main light spot, Sm, and the secondary light spot, Ss, are formed on the optical disc 10.

[0022] The light source unit 11 includes a light source 13 to produce and to emit light and an optical branching device 15 to branch the light emitted from the light source 13 into the main beam I and the sub beam II. The main beam I and the sub beam II branched by the optical branching device 15 are focused by the objective lens 21 and incident on the optical disc 10 forming as the main light spot, Sm, and the secondary light spot, Ss, respectively. The secondary light spot, Ss, is at a predetermined distance ahead of the main light spot, Sm, in the track direction along which the optical disc 10 rotates. In an exemplary embodiment, the optical branching device 15 can be a hologram element or a grating.

[0023] The light source 13 outputs light (mW) having power that satisfies the following equation:

$$Pt = (Pm + Ps)/\alpha, \quad 0 \leq \alpha \leq 99 \qquad (2)$$

[0024] where Pt denotes a total of light power output from the light source 13, Pm denotes the power of the main beam I, Ps denotes the power of the sub beam II, and α denotes a degradation in light efficiency caused by the branching of light into two beams.

[0025] Referring to FIG. 2, the optical pickup further includes a collimating lens 17, a beam splitter that is an optical path changer 19, a sensing lens 23, and a photo detector 25. The collimating lens 17 collimates diverging light emitted from the light source 13 and outputs the collimated light to the objective lens 21. The optical path changer 19 changes the path of incident light so that the light received from the light source 13 is projected to the optical disc 10, and the light reflected from the optical disc 10 is subsequently projected to the photo detector 25. The sensing lens 23 focuses the light reflected from the optical disc 10, passing through the objective lens 21, and reflected from the optical path changer 19 to the photo

detector 25. The photo detector 25 has a light receiving surface for receiving the main beam I reflected by the optical disc 10. The sub beam II reflected by the optical disc 10 and incident upon the photo detector 25 is not shown in FIG. 2 because the sub beam II is not used to detect a reproducing signal.

[0026] Hence, the optical pickup in the optical recording apparatus according to the present invention performs fast mark recording and erasing and also detects the reproducing signal by the photo detector 25 receiving the main beam I reflected by the optical disc 10.

[0027] According to the optical recording apparatus of the present invention as described above, fast erasing is accomplished at a sufficient erasing ratio as described below. The sub beam II is radiated at a predetermined distance ahead of the main beam I in the track direction along which the optical disc 10 rotates. Thus, in the above-described structure in which the main beam I and the sub beam II are emitted from the single light source 13 and branched, the secondary light spot, Ss, partially erases the existing mark while radiated at a predetermined distance ahead of the main light spot, Sm, during a recording signal period of a pulse form. The secondary light spot, Ss, is formed by branching pulse-type light output from the light source 13 during a recording signal period, so that the secondary light spot, Ss, has a pulse form having the same variation as a recording signal. Therefore, because the main light spot, Sm, completely erases the existing mark during an erasing signal period, partially erased by the secondary light spot, Ss, and records a new mark at a position of the erased mark during the recording signal period, an optimal erasing ratio can be obtained even during fast recording and/or erasing.

[0028] FIG. 3 is a diagram illustrating the erasing effect varying according to the DC erasing light power, Pe. The amorphous state of the optical disc 10 varies according to the DC erasing light power, Pe, which is the light power on the incident surface of the optical disc 10, when an optical system including the light source 13 emitting a 405nm-wavelength light and the objective lens 21 having a 0.65 numerical aperture is adopted. As shown in FIG. 4, the results of FIG. 3 are obtained by varying the DC erasing light power, Pe, by 2.0mW, 2.2mW, 2.4mW and 2.6mW with respect to 0.1mW bias power, Pb.

[0029] As can be seen from FIG. 3, crystallization proceeds well with an increase in the DC erasing light power, Pe, but the optical disc becomes rather amorphous at 2.6mW DC erasing light power, Pe. The optical disc becomes amorphous because the erasing light power exceeds a reasonable level and exceeds a temperature where recording can be performed. Therefore, a reasonable DC erasing light power, Pe, is 2.2mW to 2.4mW.

[0030] FIGS. 5A through 5C illustrate different degrees to which a mark is erased

according to varying erasing pulse signals. The results of FIGS. 5A through 5C are obtained from 2.2mW, 3.0mW and 5.0mW pulse-shaped erasing light power signals, Pe-pulse, which is the secondary light spot, Ss, during the recording signal a position in the optical disc 10 where a 4T mark is recorded at a 5.84m/s linear velocity. A pulse-type recording signal illustrated in FIG. 6 having 405nm-wavelength light and an objective lens 21 having a 0.65 numerical aperture are used to illustrate the different degrees to which the mark is erased. The minimum mark length 3T is 0.30 μm. In FIG. 6, a recording signal having a smaller width than the length of a nominal mark is applied in consideration of dispersion due to temperature of the mark formed by a phase change.

[0031] Table 1 shows a variation in carrier level (C/L) when DC erasing light power, Pe, and pulse-shaped erasing light power, Pe-pulse, are applied, as shown in FIGS. 3 and 4. The results of Table 1 are obtained with a 5.84m/s linear velocity, 6.5mW recording light power, Pw, 2.2mW erasing light power, Pe, 0.3mW bias light power, Pw, 0.4mW reproducing light power, Pr, and a 54.0dB carrier to noise ratio (C/N). Here, the carrier level is obtained by analyzing the reproducing signal of the mark using a spectrum analyzer and expressing the reproducing signal of the mark in dBm.

Table 1

	initial mark	Pe = 2.2 mW	Pe-pulse = 2.2 mW	Pe-pulse = 5.0 mW
C/L	-30dBm	-60dBm	-33dBm	-45dBm

[0032] Referring to Table 1, the carrier level of the initial 4T mark to which erasing light power has not been yet applied is -30dBm. When reasonable DC erasing light power, Pe, of 2.2mW is applied to the 4T mark, erasing is properly performed and the carrier level of the power-applied portion is reduced to -60dBm. On the other hand, when 2.2mW pulse-shaped erasing light power, Pe-pulse, which is the same size as the reasonable DC erasing light power, Pe, is applied to the 4T mark, the carrier level of the power-applied portion of the mark is - 33dBm. This carrier level means that the erasing is hardly performed. However, when 5.0mW pulse-shaped erasing light power, Pe-pulse, is applied to the 4T mark, the carrier level of the power-applied portion of the mark decreases to -45dBm. Thus, if the power-applied portion of the mark is completely erased by the reasonable DC erasing light power, Pe, of 2.2mW, a sufficient erasing ratio can be obtained.

[0033] Accordingly, if the mark is partially erased by the pulse-typed secondary light spot,

Ss, having reasonable power during a recording signal period and then completely erased by the main light spot, Sm, during an erasing signal period, as in the present invention, a sufficient erasing ratio can be obtained even during fast erasing.

[0034] In the above, an optical recording apparatus, in accordance with an exemplary embodiment of the present invention, includes the light source unit 11, having the light source 13 and the optical branching device 15 for branching light emitted from the light source 13 into the main beam I and the sub beam II has been described. However, as shown in FIG. 7, an optical recording apparatus in accordance with an alternative embodiment of the present invention may include a light source unit 30 including first and second light sources 31 and 33 installed adjacent to each other so that the optical branching device 15 of FIG. 2 can be omitted.

[0035] As shown in FIG. 7, the first and second light sources 31 and 33 are separated from each other so that a main beam I' and a sub beam II" emitted therefrom radiate on the optical disc 10 a main light spot, Sm, and a secondary light spot, Ss, respectively. The secondary light spot, Ss, is at a predetermined distance ahead of the main light spot, Sm, along information rows on the optical disc 10. The recording area to be irradiated by the main light spot, Sm, is not affected by the secondary light spot Ss. In an exemplary embodiment, the first light source 31 is arranged along the optical axis because the main beam I' emitted therefrom is used to record information and to detect a reproducing signal. The sub beam II", which is reflected by the optical disc 10 and is directed to the photo detector 25, is not shown because the sub beam II" is not used to detect a reproducing signal.

[0036] In case that the first and second light sources 31 and 33 operate in synchronization with each other, if the first and second light sources 31 and 33 output light power having the same form but different magnitudes, the main light spot, Sm, and the secondary light spot, Ss, formed by focusing the main beam I' and the sub beam II", respectively, from the first and second light sources 31 and 33 are used to record and/or erase in substantially the same manner as described in the previous embodiment . Specifically, the light emitted from the single light source 13 is branched into the main beam I and the sub beam II.

[0037] On the other hand, in case that the first and second light sources 31 and 33 operate independently, while the first light source 31 outputs pulse-formed recording light power, the second light source 33 can be driven to output DC erasing light power. In this case, an existing mark is partially erased by the secondary light spot, Ss, having DC erasing light power from the second light source 33 and then completely erased by the main light

spot, Sm, having DC erasing light power from the first light source 31, so that a sufficient erasing ratio during fast erasing is also obtained.

[0038] According to the present invention as described above, a main light spot and a secondary light spot radiated at a predetermined distance ahead of the main light spot in the track direction of an optical disc are formed on the optical disc, and, while a mark is recorded by the main light spot in response to a recording signal, an existing mark is partially erased by the secondary light spot during a recording signal period and then completely erased by the main light spot during an erasing signal period. Thus, an optimal erasing ratio can be obtained even during fast mark recording and/or erasing. In the present invention, the mark can be fast recorded on an optical disc, and fast mark recording can be achieved in the case of the optical disc having no special crystallization accelerating layers for accelerating erasing.

[0039] While this invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made thereto without departing from the spirit and scope of the invention as defined by the appended claims.